

**Mineralogical study of the seafloor diagenesis of carbonate sediments
near Dry Tortugas, Gulf of Mexico,
using Rietveld method of crystal structure refinement**

by

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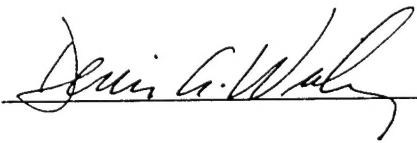
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1. Introduction

Sediment microstructure is largely determined by chemical diagenesis and physical processes such as bioturbation and storm reworking in the carbonate sediments of Fort Jefferson National Monument area, west of Key West, Florida. Consequently, understanding of the extent of chemical diagenesis and physical reworking is essential in order to understand the sediment structure as well as the geophysical and geoacoustic properties affected by the sediment structure. This on-going study investigates the mineralogy, porewater geochemistry, and sediment microstructure of a number of box and gravity cores from the study area in order to quantify the extent of chemical diagenesis. This quarterly technical report summarizes the results of mineralogical study, whereas preliminary results of geochemical and microfabric study are presented in the previous technical reports (Furukawa, 1995a, b, c)

This study, funded by the Naval Research Laboratory (NRL), is a part of the large research program managed by the Office of Naval Research (ONR) called Coastal Benthic Boundary Layer Special Research Program (CBBL-SRP). The objective of the CBBL-SRP is to characterize and model benthic boundary layer processes and the impact such processes cause on seafloor properties that affect shallow-water naval operation (Richardson, 1995). The present study investigates the chemical diagenesis in an attempt to understand the relationship between sediment structure and processes that form the structure, chemical diagenesis, sedimentation and physical reworking.

2. Methods

The author participated in the CBBL-SRP Key West Campaign that was conducted in the area of carbonate sediments near Dry Tortugas (Fort Jefferson National Monument) and Marquesas Keys, west of Key West, Florida in the Gulf of Mexico. Dry Tortugas area sediments were sampled extensively to study mineralogy. Results from several box cores (KW-PL-BC-141, 165, 194), a diver core (KW-PL-DC-178), and a gravity core (KW-PE-GC-147) are reported herein. Sediments near Marquesas Keys were collected also and results from a box core (KW-PL-BC-208) are reported herein. The same box, diver and gravity cores were subsampled also for pore water chemistry and microfabric. The chemistry and microfabric results are presented in previous technical reports (Furukawa, 1995a, b, c).

Mineralogy is studied using X-ray powder diffraction (XRD) and the subsequent Rietveld method of crystal structure refinement (Rietveld, 1969; Young, 1995; Young et al., 1994). For some samples (KW-PE-GC-147), clay, silt, and sand fractions were separated using settling and siphoning in order to study the size-fraction mineralogy. The Rietveld method of refinement is capable of quantifying the calcium carbonate phases with various Mg contents (Bish and Post 1993). The Rietveld method also provides the cell constants of high-Mg and low-Mg calcites from which Mg contents can be calculated using the existing correlation curve (Goldsmith et al., 1958; Reid et al., 1993).

3. Results

The XRD profiles of bulk samples from the box and diver cores are shown in Figures 1-5. The XRD profiles of the gravity core are shown in Figure 6 for the bulk samples, and in Figures 7-9 for sand, silt and clay fraction samples. The peaks indicate that the sediments are a mixture of aragonite, high-Mg calcite, low-Mg calcite, and non-carbonate fraction that is dominated by quartz. Note the relative intensities of high-Mg calcite and low-Mg calcite peaks. Whereas the relative intensities remain nearly constant through the box and gravity core sampling depths, they change significantly at depths in clay fraction of the gravity core samples.

The Rietveld method of crystal structure refinement quantified the change in relative amount of high-Mg calcite (HMC) and low-Mg calcite (LMC) in clay, silt, and sand fractions of samples from KW-PE-GC-147 (Figure 10). The HMC/LMC ratio increases at depths in the clay fraction.

4. Discussion

The increase in HMC/LMC calcite ratio in a gravity core below 120 cm (Figure 10) may be the result of cementation. Most cement in shallow water sediments is either high-Mg calcite or aragonite (Bathurst, 1975). Because the effect of cementation should be more notable within the matrix than around the surface of grains, due to the surface area difference, the comparison of matrix (i.e., clay) mineralogy vs. grain (i.e., silt and sand) mineralogy clarifies the reason for the observed shift. Because the observed shift in HMC/LMC ratio comes from cementation, the clay mineralogy shows the HMC/LMC increase at depth whereas the grain mineralogy remains constant. If the shift had been from the difference in depositional environment that results in more primary HMC grains (e.g., red algae and benthic foraminefera) at depth, both matrix mineralogy and grain mineralogy would have shown the shift. The lack of shift within the upper 120 cm of the sediments may be due to the physical reworking and/or lack of cementation. Cementation may become significant right below the mixing layer, or may not be detectable by mineralogy until the sediment is buried without mixing for a long period of time.

5. Further study

More quantitative mineralogy using the Rietveld method is planned. Further microfabric study using scanning electron microscope (SEM) is underway. The results will be combined with mineralogy and pore water chemistry and presented at Mississippi Academy of Sciences meeting in February 1996.

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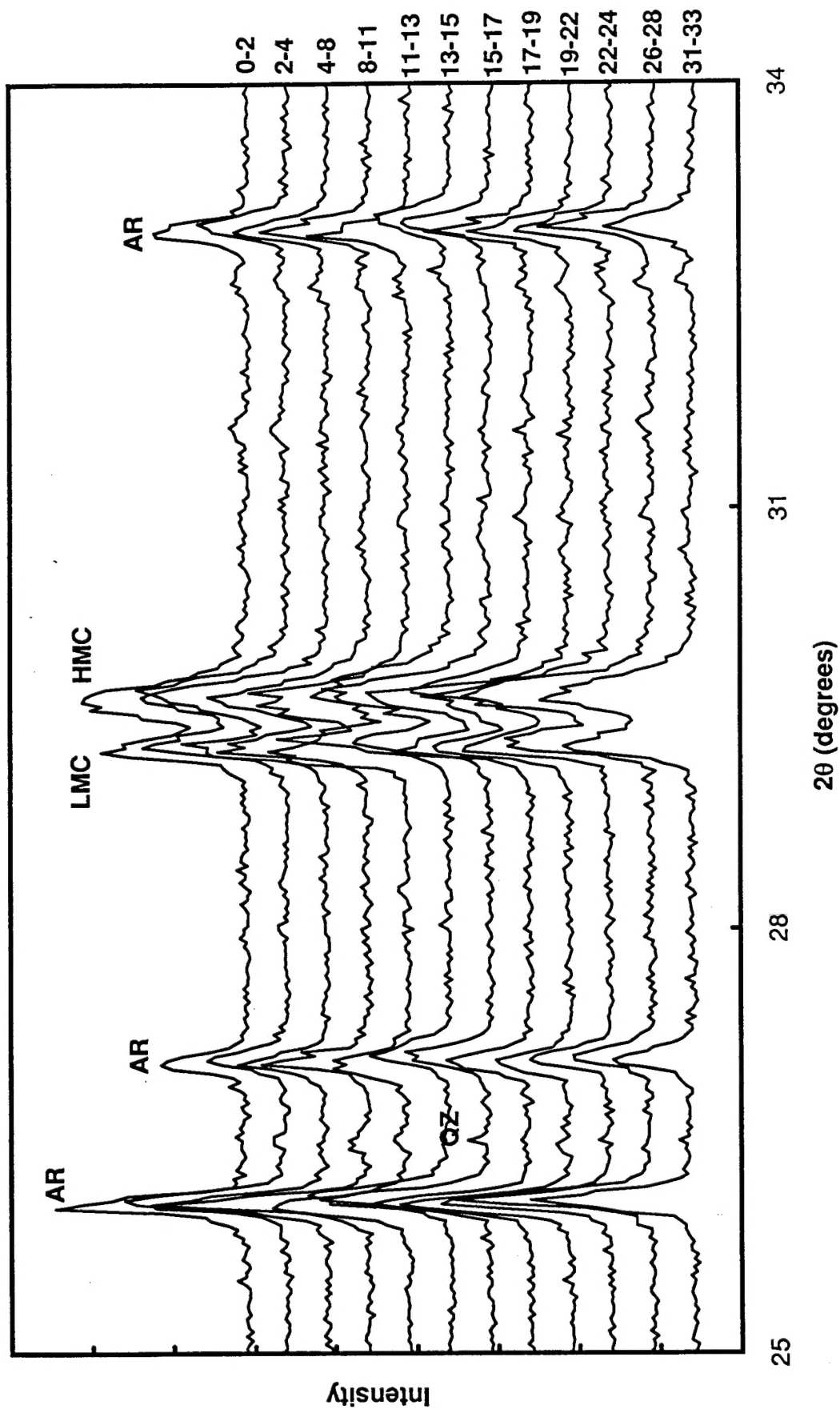


Figure 1. X-ray powder diffraction profiles of bulk sediment samples from KW-PL-BC-141. Sample depths are indicated on the right in terms of centimeters below seafloor. AR, aragonite; LMC, low-Mg calcite; HMC, high-Mg calcite; QZ, quartz.

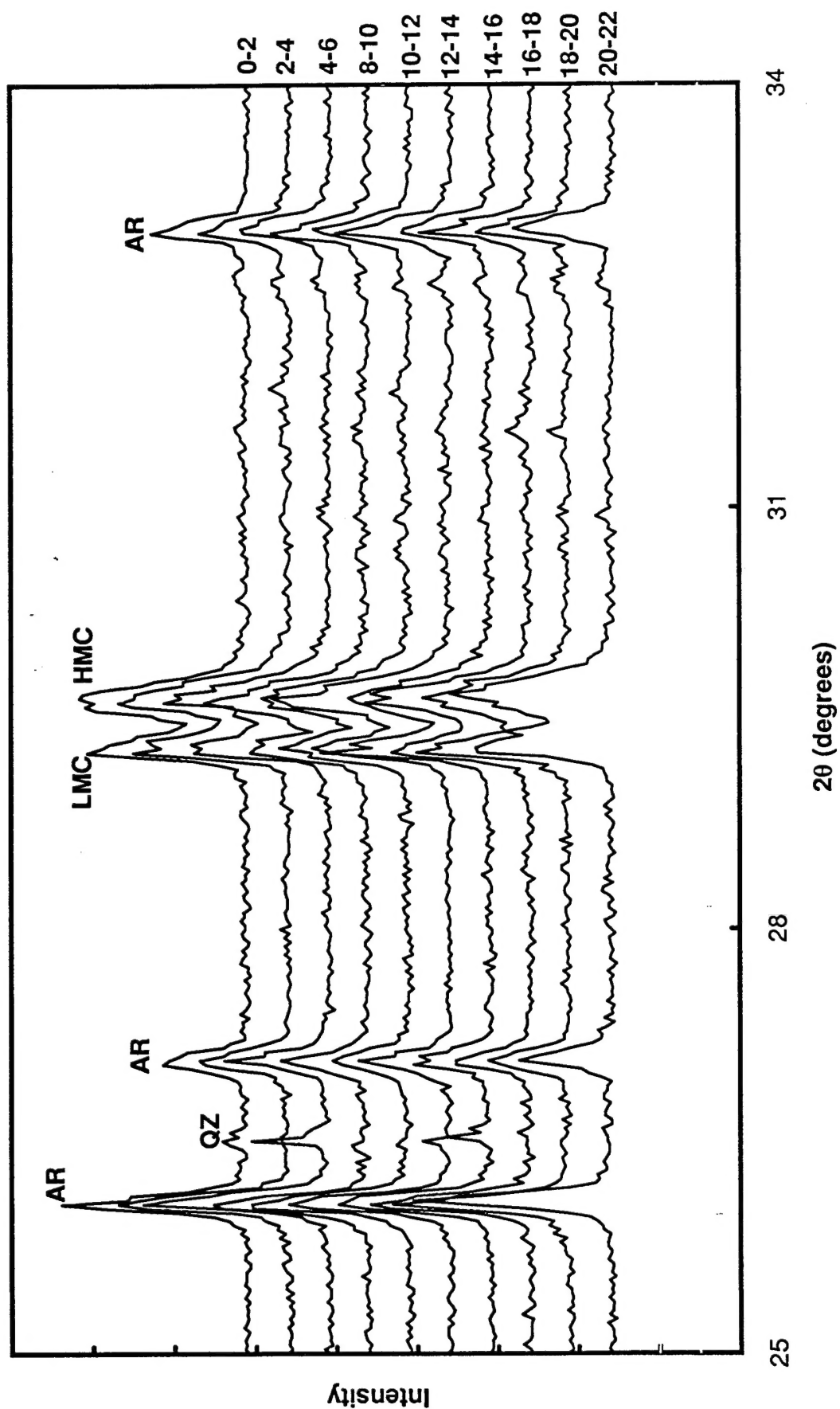


Figure 2. X-ray powder diffraction profiles of bulk sediment samples from KW-PL-BC-165. Sample depths are indicated on the right in terms of centimeters below seafloor. AR, aragonite; LMC, low-Mg calcite; HMC, high-Mg calcite; QZ, quartz.

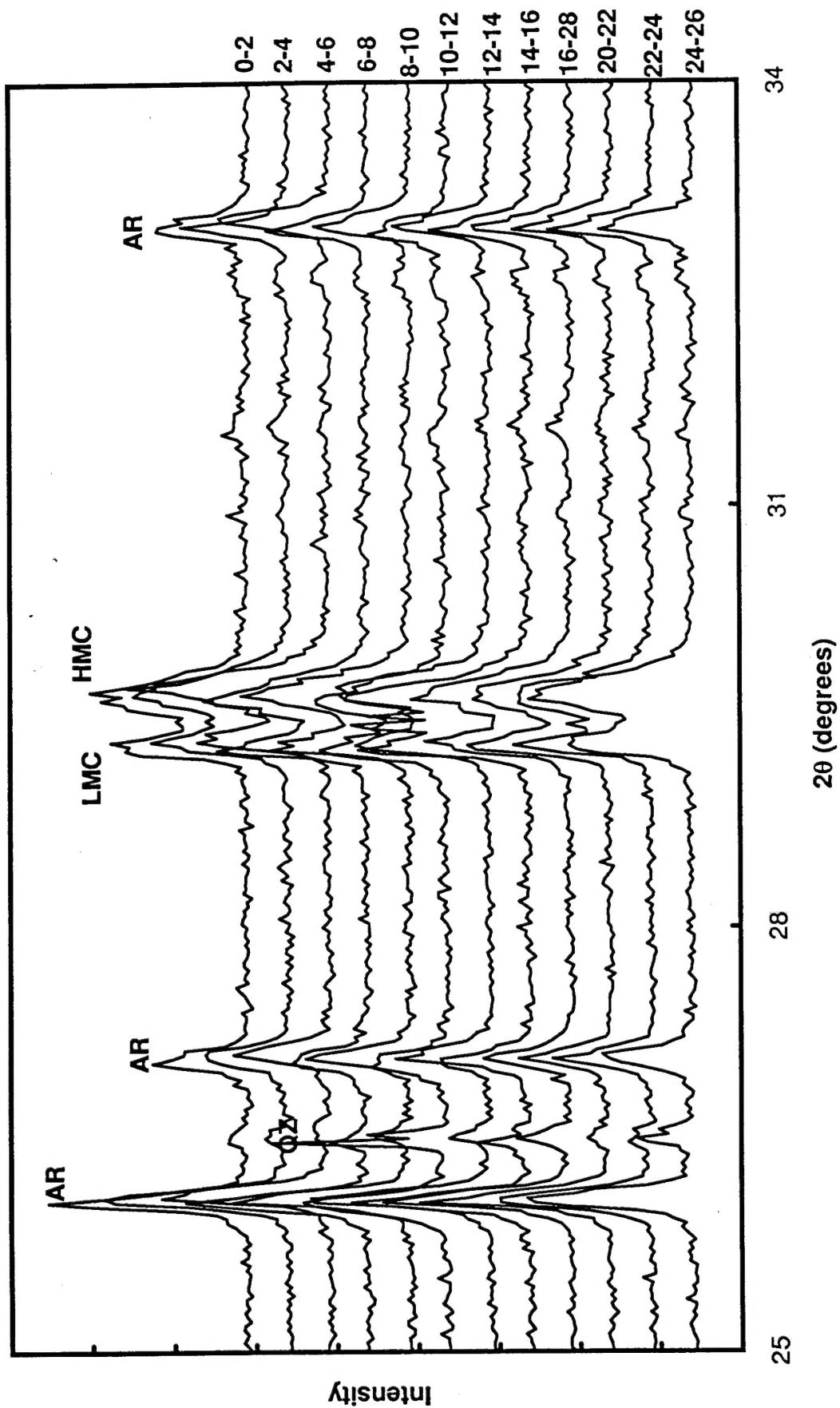


Figure 3. X-ray powder diffraction profiles of bulk sediment samples from KW-PL-DC-178. Sample depths are indicated on the right in terms of centimeters below seafloor. AR, aragonite; LMC, low-Mg calcite; HMC, high-Mg calcite; QZ, quartz.

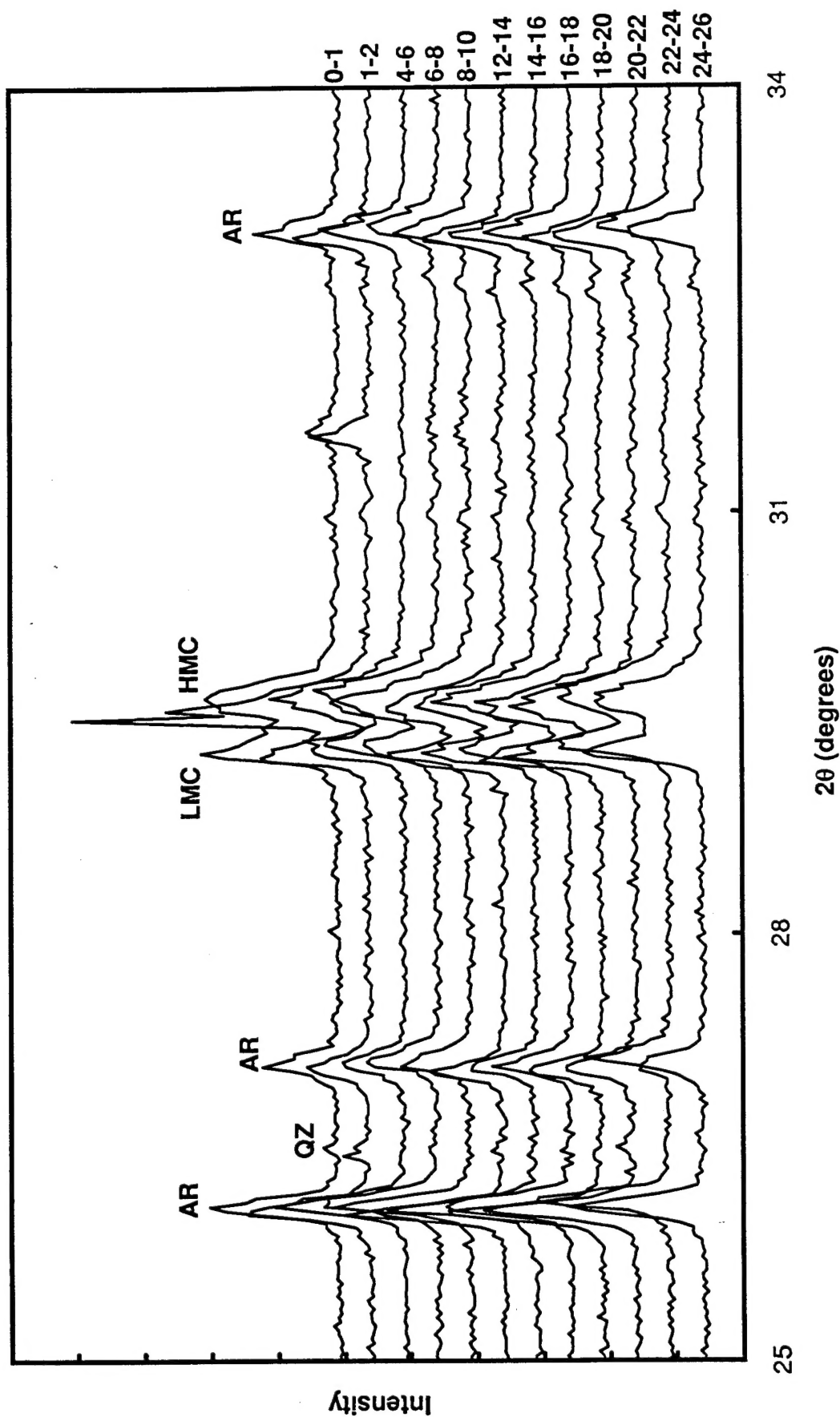


Figure 4. X-ray powder diffraction profiles of bulk sediment samples from KW-PL-BC-194. Sample depths are indicated on the right in terms of centimeters below seafloor. AR, aragonite; LMC, low-Mg calcite; HMC, high-Mg calcite; QZ, quartz.

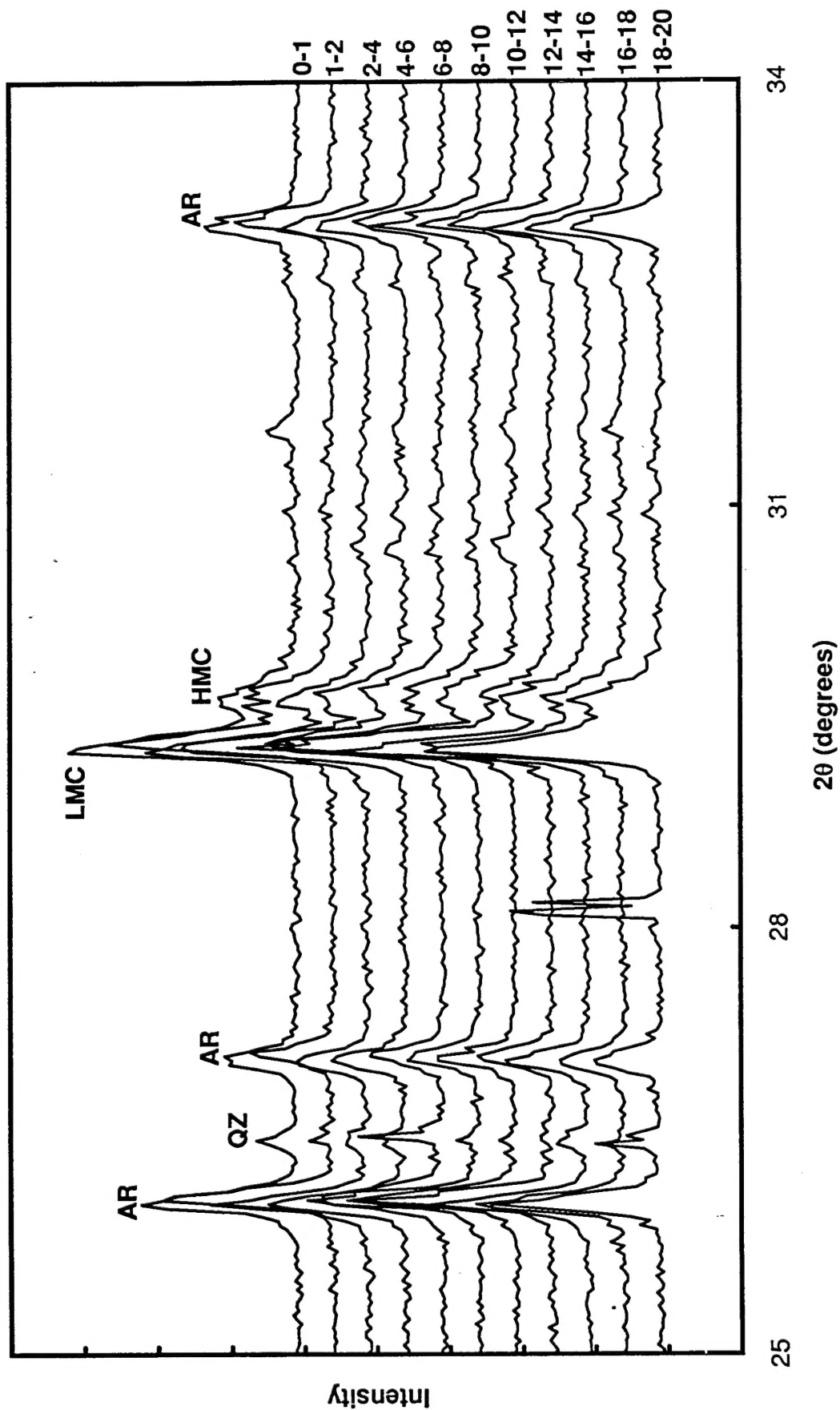


Figure 5. X-ray powder diffraction profiles of bulk sediment samples from KW-PL-BC-208. Sample depths are indicated on the right in terms of centimeters below seafloor. AR, aragonite; LMC, low-Mg calcite; HMC, high-Mg calcite; QZ, quartz.

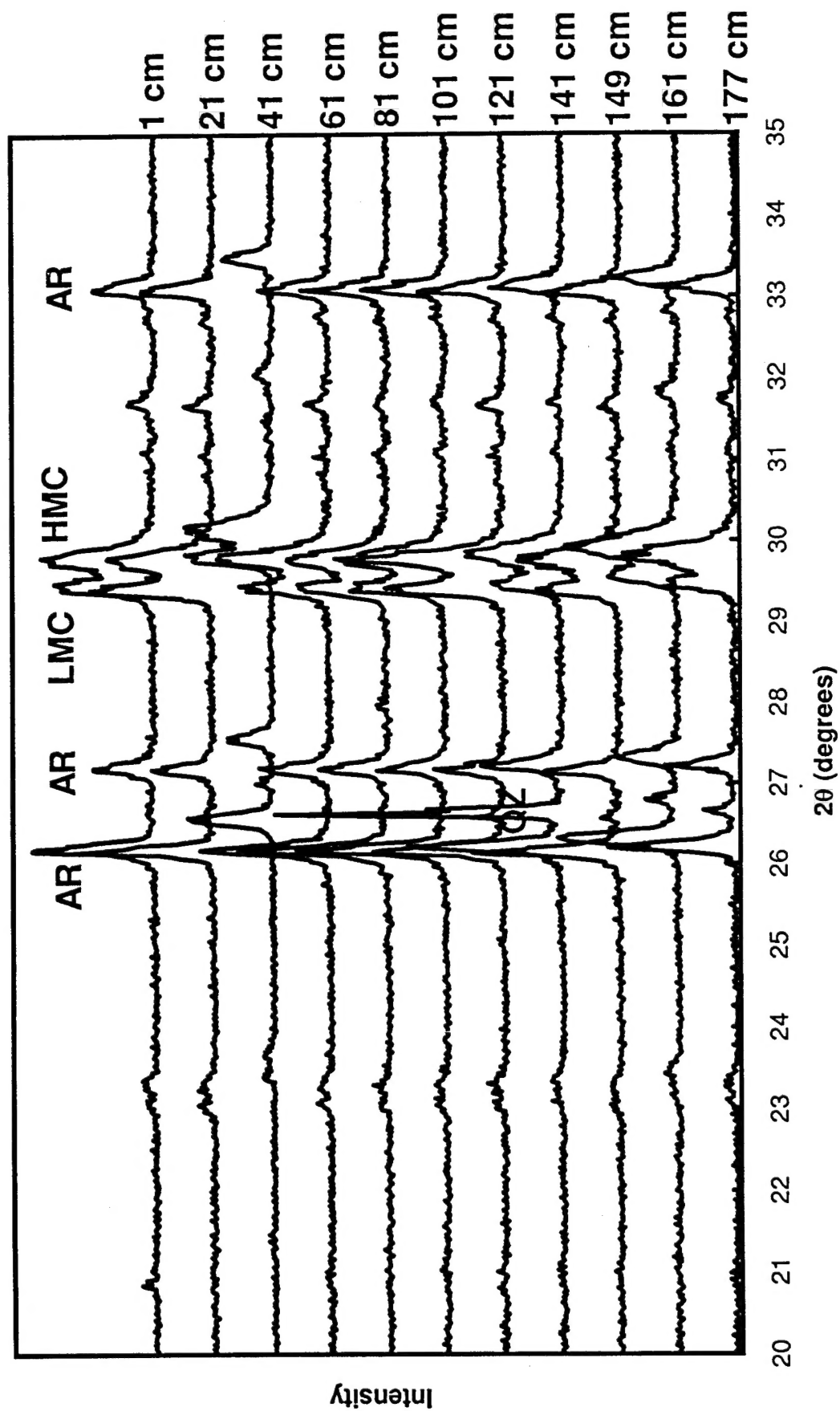


Figure 6. X-ray powder diffraction profiles of bulk sediment samples from KW-PE-GC-147.

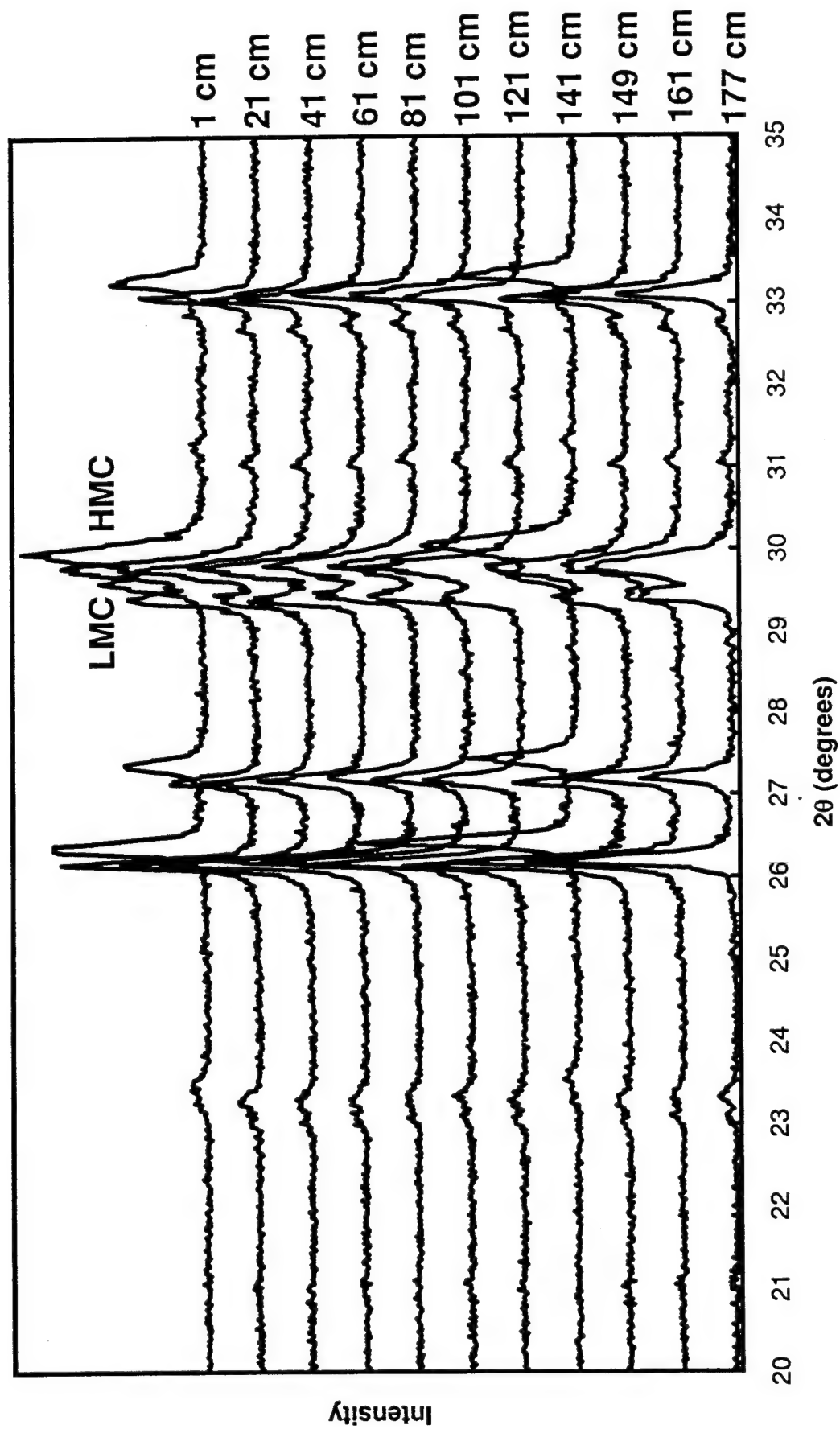


Figure 7. X-ray powder diffraction profiles of sand fraction samples from KW-PE-GC-147.

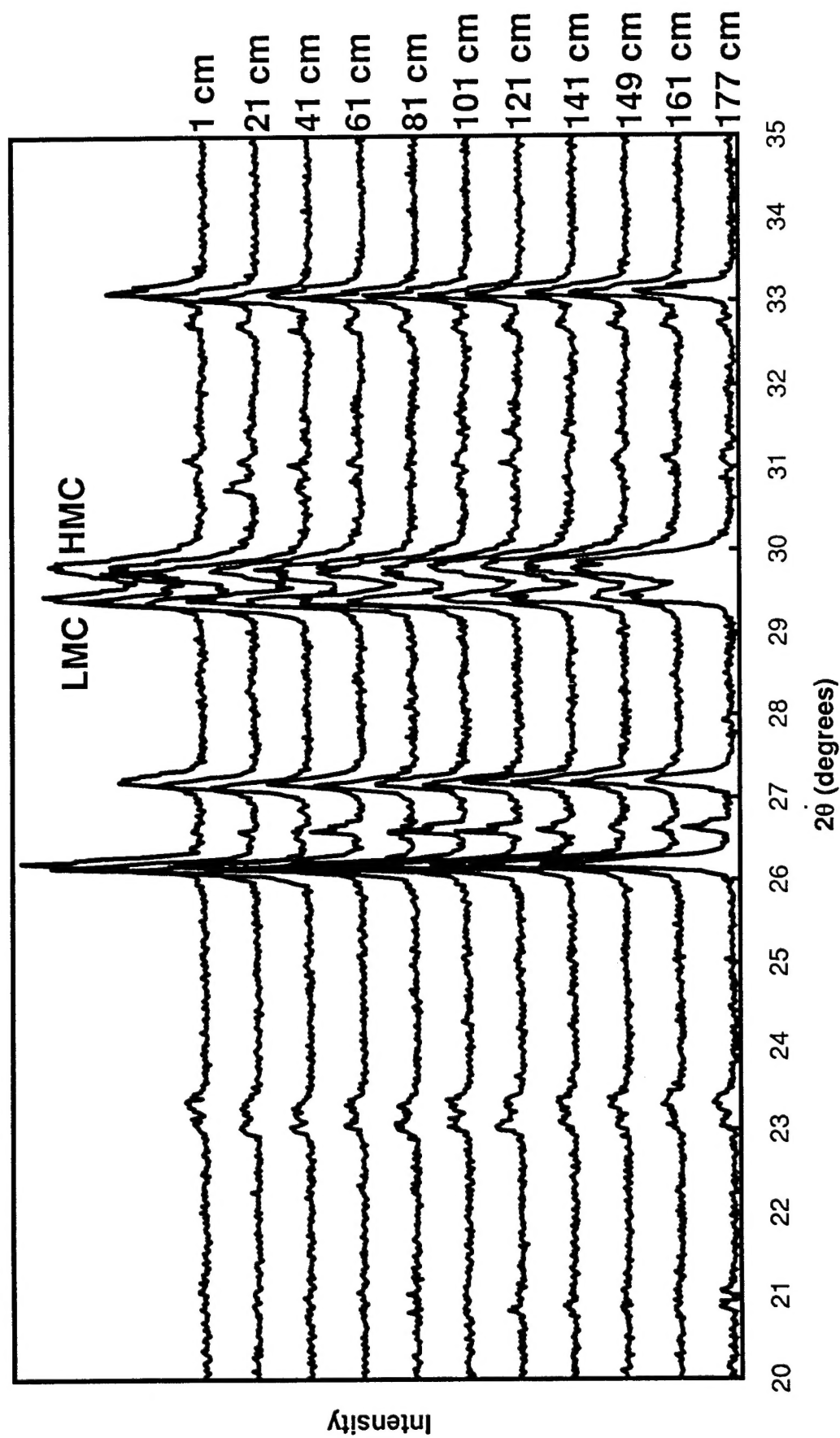


Figure 8. X-ray powder diffraction profiles of silt fraction samples from KW-PE-GC-147.

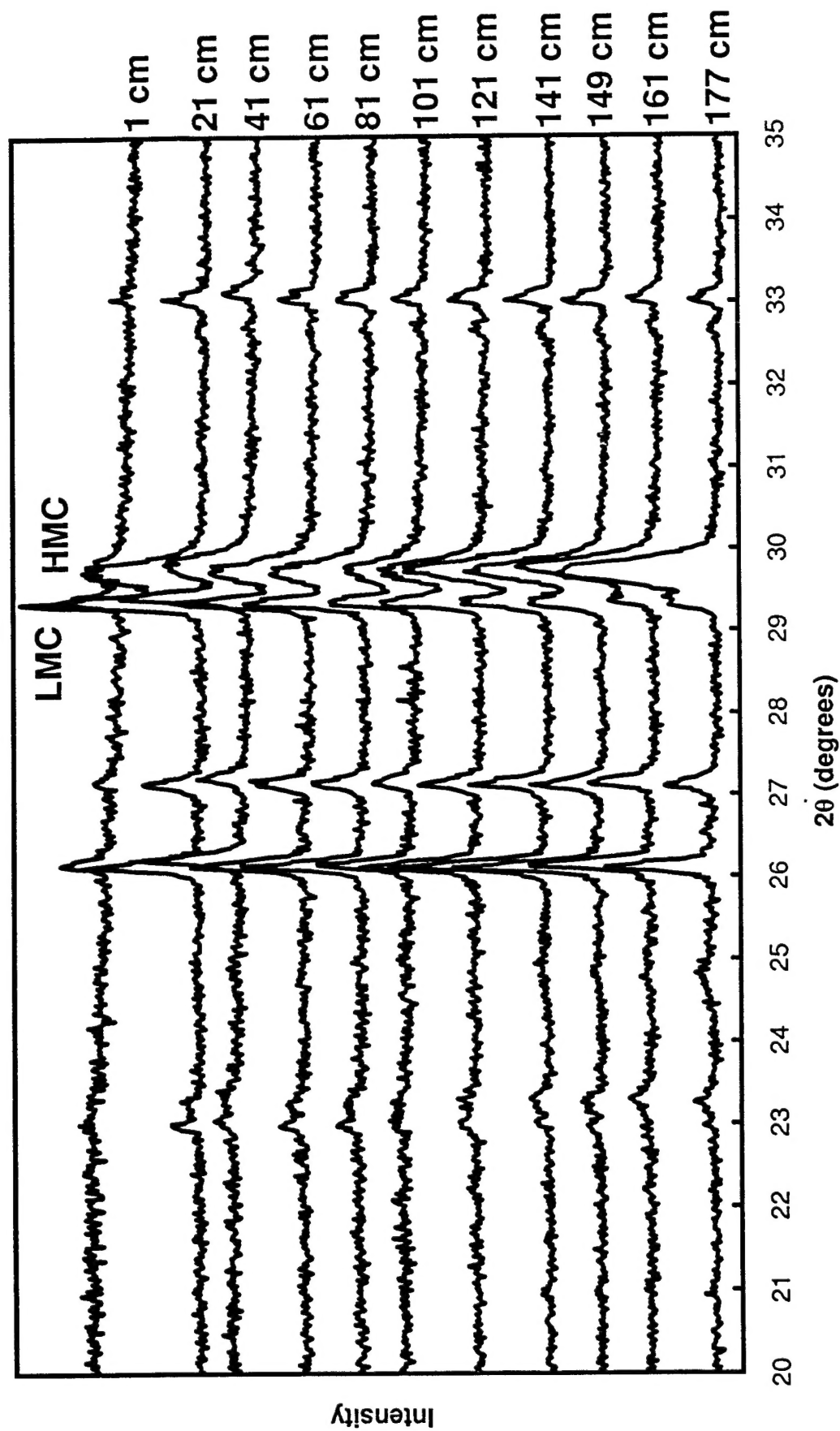


Figure 9. X-ray powder diffraction profiles of clay fraction samples from KW-PE-GC-147.

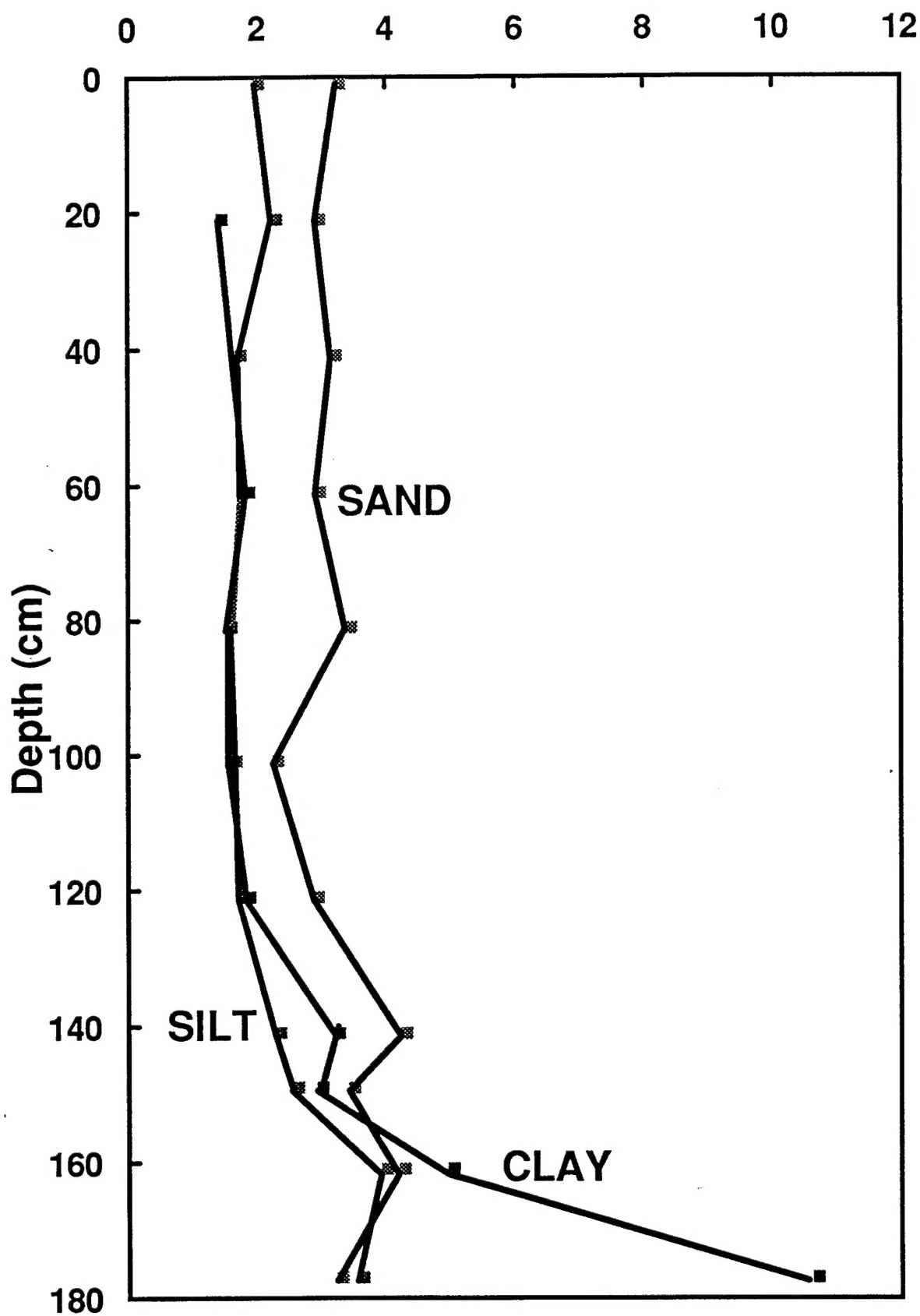


Figure 10. HMC/LMC ratio of size-fractioned samples from KW-PE-GC-147.

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